WACCM-X:

The Whole Atmosphere Community Climate Model - eXtended

WACCM-X is a model of the entire atmosphere that extends into the thermosphere to ~500 km altitude, and includes the ionosphere. It is the work of many people at the National Center for Atmospheric Research in the Geospace section of the High Altitude Observatory, in the Atmospheric Chemistry, Observations, and Modeling Laboratory, the Climate and Global Dynamics division, and external collaborators.

WACCM-X is built on WACCM

WACCM is built on CAM

CAM is the NCAR Community Atmosphere Model

CAM, WACCM, and WACCM-X are run as the atmospheric component within the Community Earth System Model (CESM), which also includes components for land, oceans, sea ice, and land ice.

Why WACCM-X?

Because the thermosphere- ionosphere system responds to variability from the Earth's lower atmosphere as well as solar-driven "space weather"

Including:

- Waves and tides
- Tropospheric weather
- Middle-atmosphere events
- Seasonal variations
- Anthropogenic trace gases

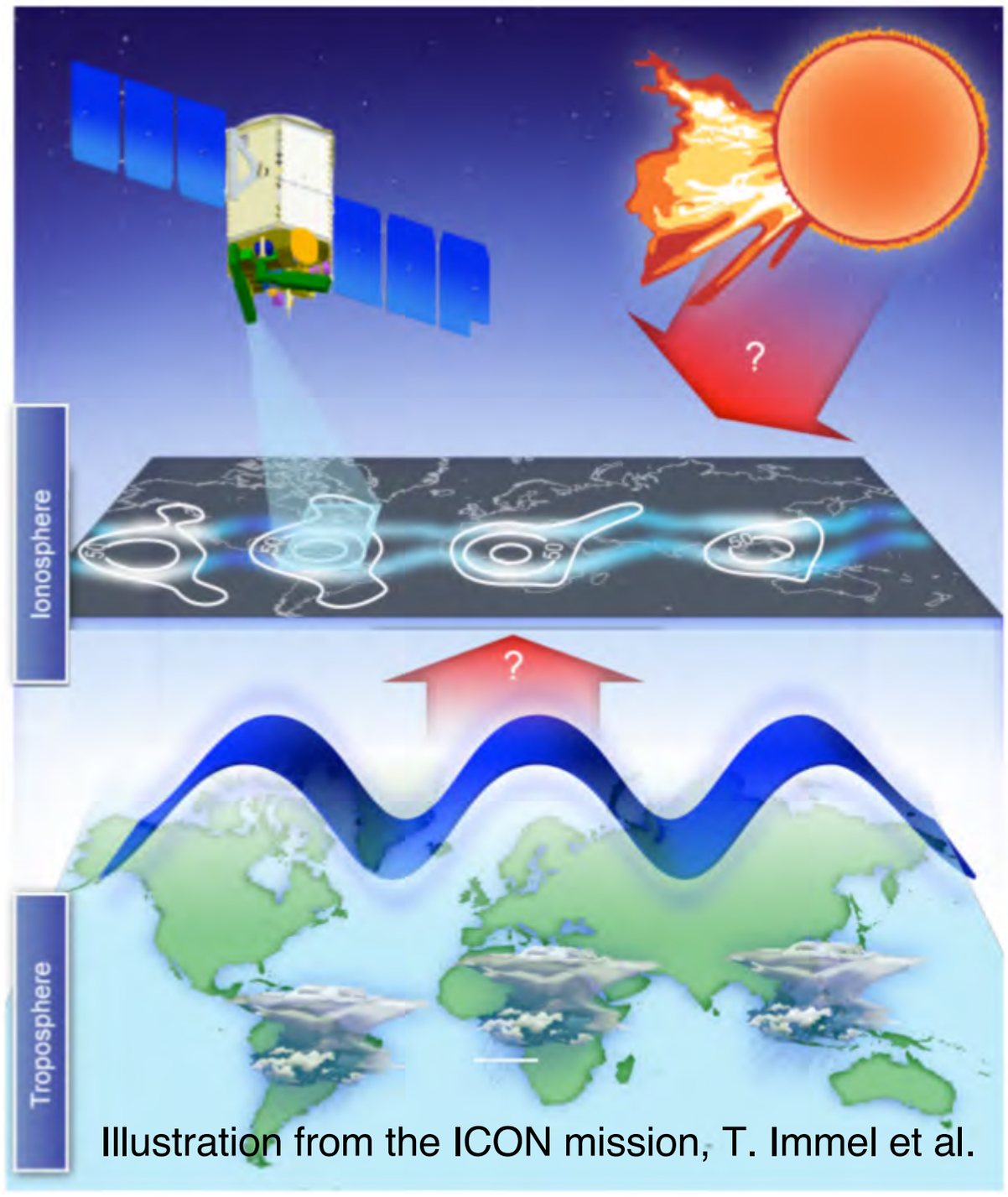
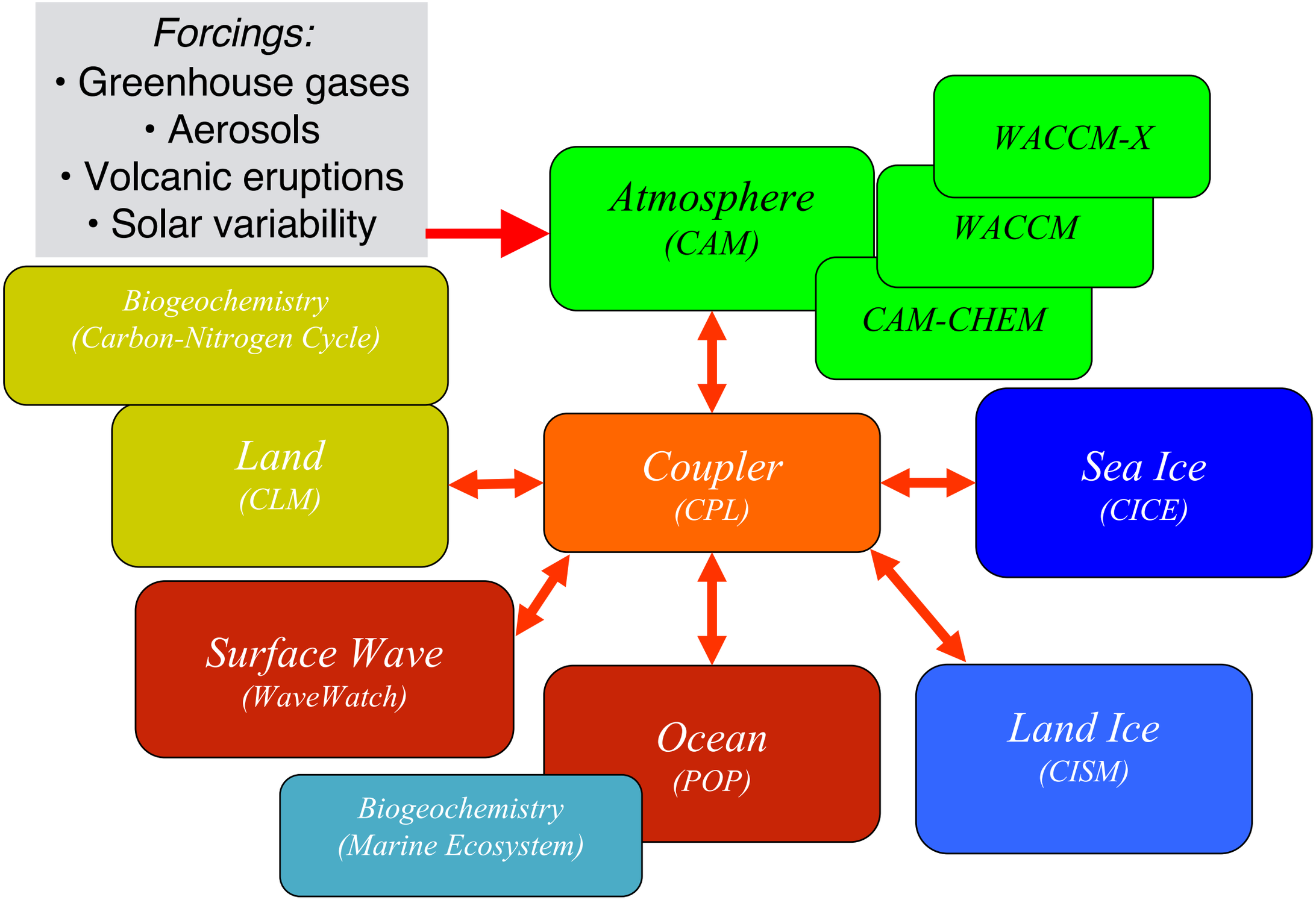


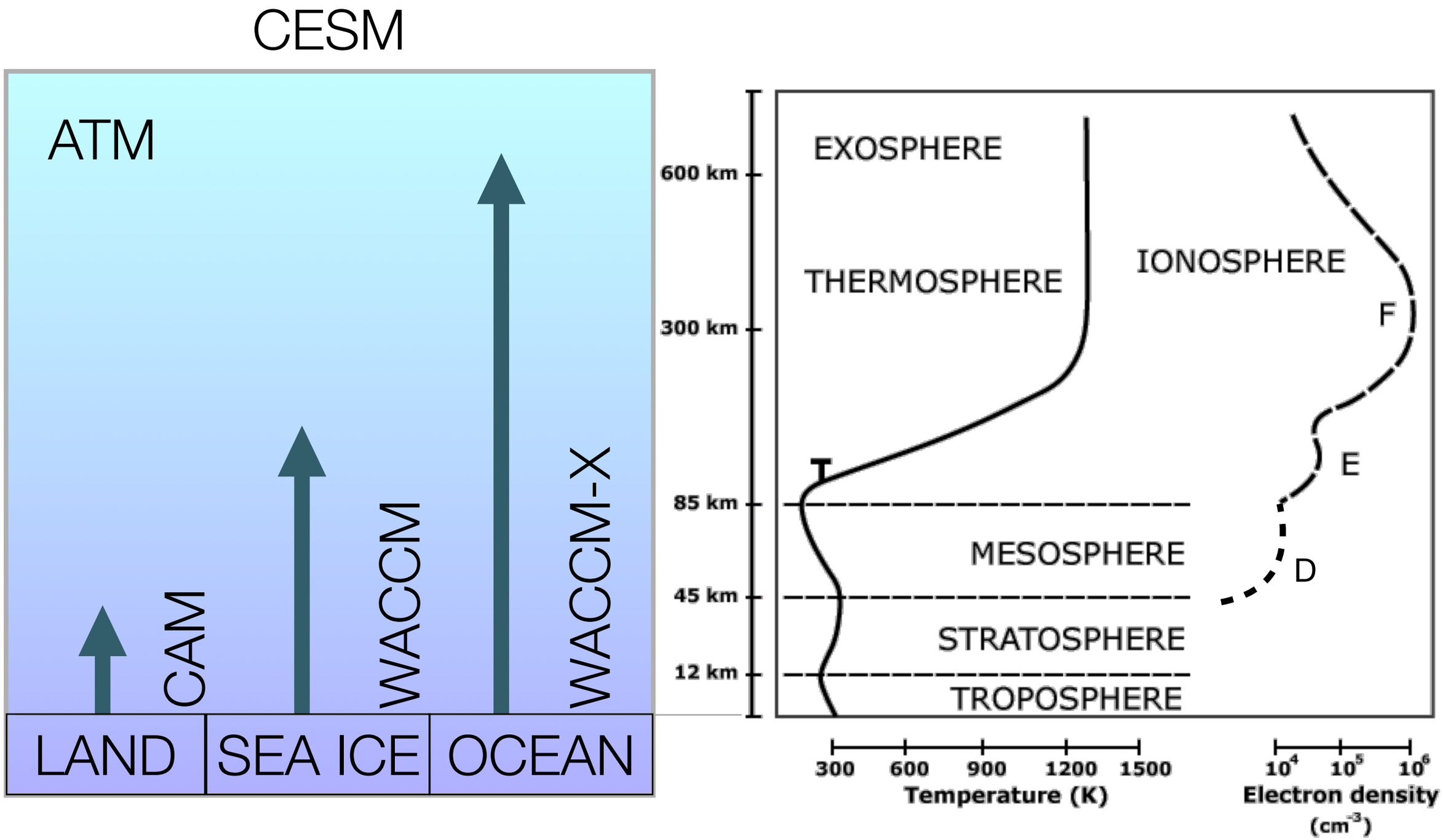
Illustration from the ICON mission, T. Immel et al.

CESM components

Forcings:
- Greenhouse gases
- Aerosols
- Volcanic eruptions
- Solar variability



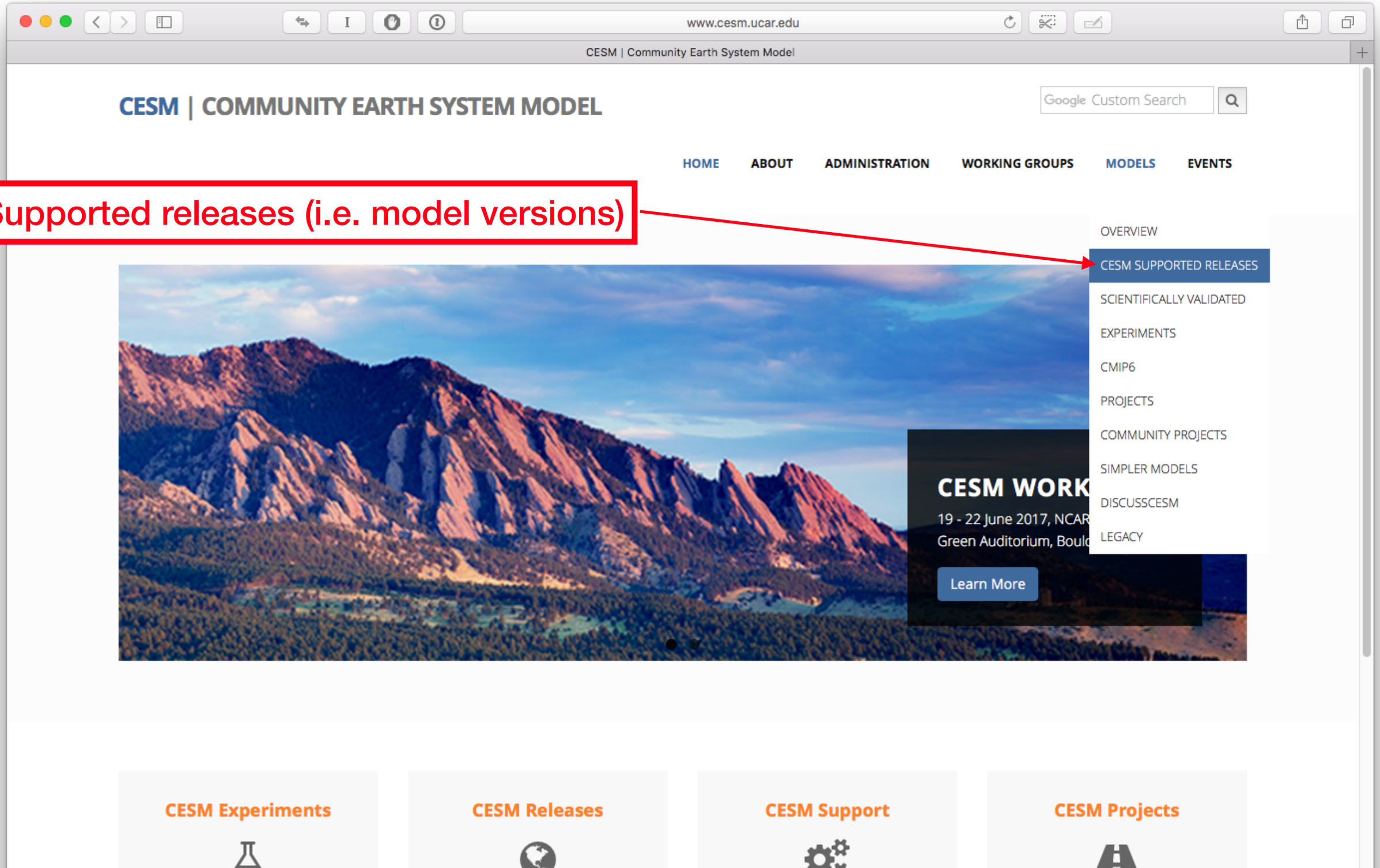
NCAR Community Earth System Model (CESM)
atmosphere components



CESM2: WACCM6 & WACCM-X

	WACCM6	WACCM-X
# levels	70-88	125-145
model top	$6x10^{-6}$ hPa (~140 km)	$4x10^{-10}$ hPa (500~600 km)
Horizontal resolution	0.95˚x1.25˚	1.9˚x2.5˚
Time step	30 min.	5 min.
Specified Dynamics	X	X
Chemistry	TSMLT, MA	MA
Non-orographic GW	X	X
Molecular diffusion	minor	minor and major
Auroral physics	X	X
Ions	E-region or E&D-region	E-region
Ion transport		X
E Dynamo		X

CESM Web Page: http://www.cesm.ucar.edu



CESM Models Web Page:

http://www.cesm.ucar.edu/models/current.html

www.cesm.ucar.edu/models/current.html

CESM Models | CESM Supported Releases

CESM | COMMUNITY EARTH SYSTEM MODEL

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/ CESM Models / CESM Supported Releases

Latest release is CESM1.2 (CESM2.0 coming soon)

CESM Models | CESM Supported Releases

You should use the most recent version of the model that is available unless you are trying to replicate previous results or create a branch run from a previous experiment. A complete list of CESM scientifically validated configurations is available for users needing to run the model in one of these configurations.

This table lists the most current supported CESM release versions.

Supported CESM Release Versions	
CESM1.2.z	Release Notes includes: What's New - Science, What's New - Software, Answer-Changing Features, Supported Machines, and Known Problems
CESM 1.1.z	Notable Improvements
CESM 1.0.z	Notable Improvements

CESM Model Version Naming Conventions

CESM X.Y.Z - CESM model release versions include three numbers separated by a dot (.) where:

- X - corresponds to the major release number indicating significant science changes.
- Y - corresponds to the addition of new infrastructure and new science capabilities for targeted components.
- Z - corresponds to release bug fixes and machine updates.

CESM Project

CESM is a fully-coupled, community, global climate model that provides state-of-the-art computer simulations of the Earth's past, present, and future climate states.

CESM is sponsored by the National Science Foundation (NSF) and the U.S. Department of Energy (DOE). Administration of the CESM is maintained by the Climate and Global Dynamics Laboratory (CGD) at the National Center for Atmospheric Research (NCAR).

CESM Models

Overview

Supported Releases

Scientifically Validated Configurations

Experiments

www.cesm.ucar.edu/models/cesm2.0/

CESM2 Series Public Release

CESM | COMMUNITY EARTH SYSTEM MODEL

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/ CESM Models / CESM2 Series Public Release

In Development - CESM2

About CESM2

TO DO Brief Description of CESM2

- What's New in CESM2
- CESM2 Supported Release Tags and Notes

Scientific Validation

Scientific validation consists of a multi-decadal model run of the given component set at the target resolution, followed by scientific review of the model output diagnostics. All scientifically supported component sets are also accompanied by diagnostic and model output data.

- Experiment Diagnostics
- Experiment Output Datasets on the Earth Systems Grid
- Experiment Case Naming Conventions
- Experiment Output File Naming Conventions

Quick Start Documentation

- CESM2 Quick Start Guide
- CESM2 CASEROOT XML File Settings
- Register and Download
- Getting Help - DiscussCESM Forums

CIME - Documentation

- Common Infrastructure for Modeling the Earth (CIME) User's Guides
  Includes CIME, Driver-Coupler and Data Models Documentation

CESM Project

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model that provides state
simulations of the Earth's past, present, and future climate states.

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Related Information

Downloading the CESM Code

CESM Data Management & Distribution Plan

CESM Development Project Policies & Terms of Use

CESM Support Policy

DiscussCESM Forums Bulletin Board

CESM2.0 Web Page Under Development: http://www.cesm.ucar.edu/models/cesm2.0/

CESM2.0 Web Page Under Development: http://www.cesm.ucar.edu/models/cesm2.0/

Prognostic Components

Each model component page contains descriptions and documentation for active or prognostic models.

- Atmosphere
- Land
- Land Ice
- Ocean
- Sea Ice
- River Runoff
- Wave

Component Sets, Model Grids, and Machines

TODO - update just prior to release

- Component Sets (compsets)
- Grid Resolutions
- Supported Machines

Component Namelists

TODO - update just prior to release

- Component Namelists

Performance Data

- Performance and Load Balancing Data
- Running CESM2 on a Small Linux Cluster

External Library Documentation

- Parallel I/O Library (PIO)
- Model Coupling Toolkit (MCT)
- Earth System Modeling Framework (ESMF)
- * External Python Based Tools
  *** Support for these tools is currently limited to NCAR machines only!**. Access to these external python based tools are being provided to the community via NCAR Github repositories.

Model Input Data

The input data necessary to run all supported component sets is made available from a public Subversion input data repository. Note that the inputdata repository has much more data in it than you need to run CESM ---- **DO NOT attempt to svn checkout the whole input data repository**. The CIME User's Guide explains how to obtain the subset of input data required for your needs.

How do I get the WACCM data?

10 Tb of WX output have been placed on the NCAR Earth System Grid

A small (150mb) sample is available at:

https://acomstaff.acom.ucar.edu/marsh/Data/waccmx/

Community Earth System Model

CESM

https://www.earthsystemgrid.org

Earth System Grid at NCAR

Search

Home Search Projects About Contact Dan Marsh

Search Results

fxsd Search Clear Search Search Help

Search for “fxsd"

Frequency

Daily Average (1)
Monthly Average (1)

1 - 5 of 5 results Show: 20 50 100

Download Selected

- CCSM run f.e20.FXSD.f19_f19.001, Atmosphere History Data, 5-day Averages, version 1
- CCSM run f.e20.FXSD.f19_f19.001, Atmosphere History Data, Daily Averages, version 1
- CCSM run f.e20.FXSD.f19_f19.001, Atmosphere History Data, Daily Instantaneous Values, version 1
- CCSM run f.e20.FXSD.f19_f19.001, Atmosphere History Data, Hourly Instantaneous Values, version 1
- CCSM run f.e20.FXSD.f19_f19.001, Atmosphere History Data, Monthly Averages, version 1

NCAR

WACCM

Whole Atmosphere Community Climate Model

WACCM-X output

- **netCDF:** self-describing binary data format used for primary CESM output
- **History files:** WACCM-X output is written to several output streams, each with a particular frequency and averaging characteristic
  - **h0:** monthly averages
    - f.e20.FXSD.f19_f19.001.cam.h0.2000-01.nc (January 2000)
    - f.e20.FXSD.f19_f19.001.cam.h0.2000-02.nc (February 2000)
  - **h1:** hourly instantaneous
    - f.e20.FXSD.f19_f19.001.cam.h1.2000-01-01-00000.nc (January 1, 2000)
    - f.e20.FXSD.f19_f19.001.cam.h1.2000-01-01-00000.nc (January 2, 2000)
  - **h2:** daily instantaneous
  - **h3:** daily averages
  - **h4:** 5-day averages
  - **h5:** daily averages, zonal mean circulation diagnostics

https://www.earthsystemgrid.org

Dataset

CCSM4/CESM Model Output

CESM run f.e20.FXSD.f19_f19.001 data

CCSM run f.e20.FXSD.f19_f19.001, Atmosphere History Data, Hourly Instantaneous Values, version 1

Summary | *History*

Identifier
ucar.cgd.ccsm4.f.e20.FXSD.f19_f19.001.atm.hist.hourly_inst

Date Created
2017-06-21 18:15:08

Date Last Updated
2017-06-21 18:15:08

Yesterday!

Authoritative Source
tds.ucar.edu

Topic
Climate

Data Format
NetCDF (Network Commmon Data Format)

Time Frequency(ies)
hourly_inst

Select ‘Download Options’

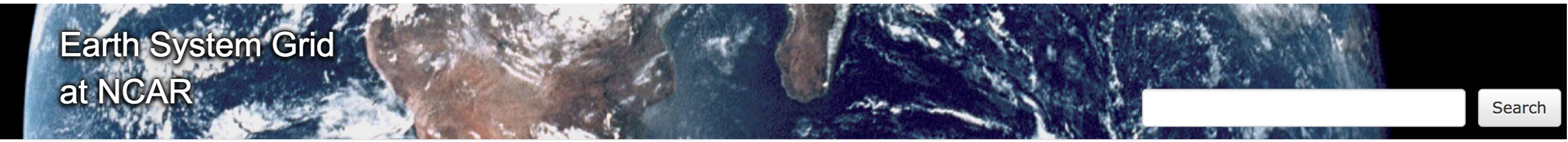
Download Options

Related Activities

Project - CCSM

Experiment - f.e20.FXSD.f19_f19.001

https://www.earthsystemgrid.org/dataset/ucar.cgd.ccsm4.f.e20.FXSD.f19_f19.001.html



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Download Files

Files can be downloaded through a Web Browser, downloaded in bulk via a WGET script, or requested from our Deep Storage Archives (SRM).

Filter Files

Filter by Filename

Use * for a wildcard character.

Apply Filter

File Download Selection

CCSM run f.e20.FXSD.f19_f19.001, Atmosphere History Data, Hourly Instantaneous Values, version 1

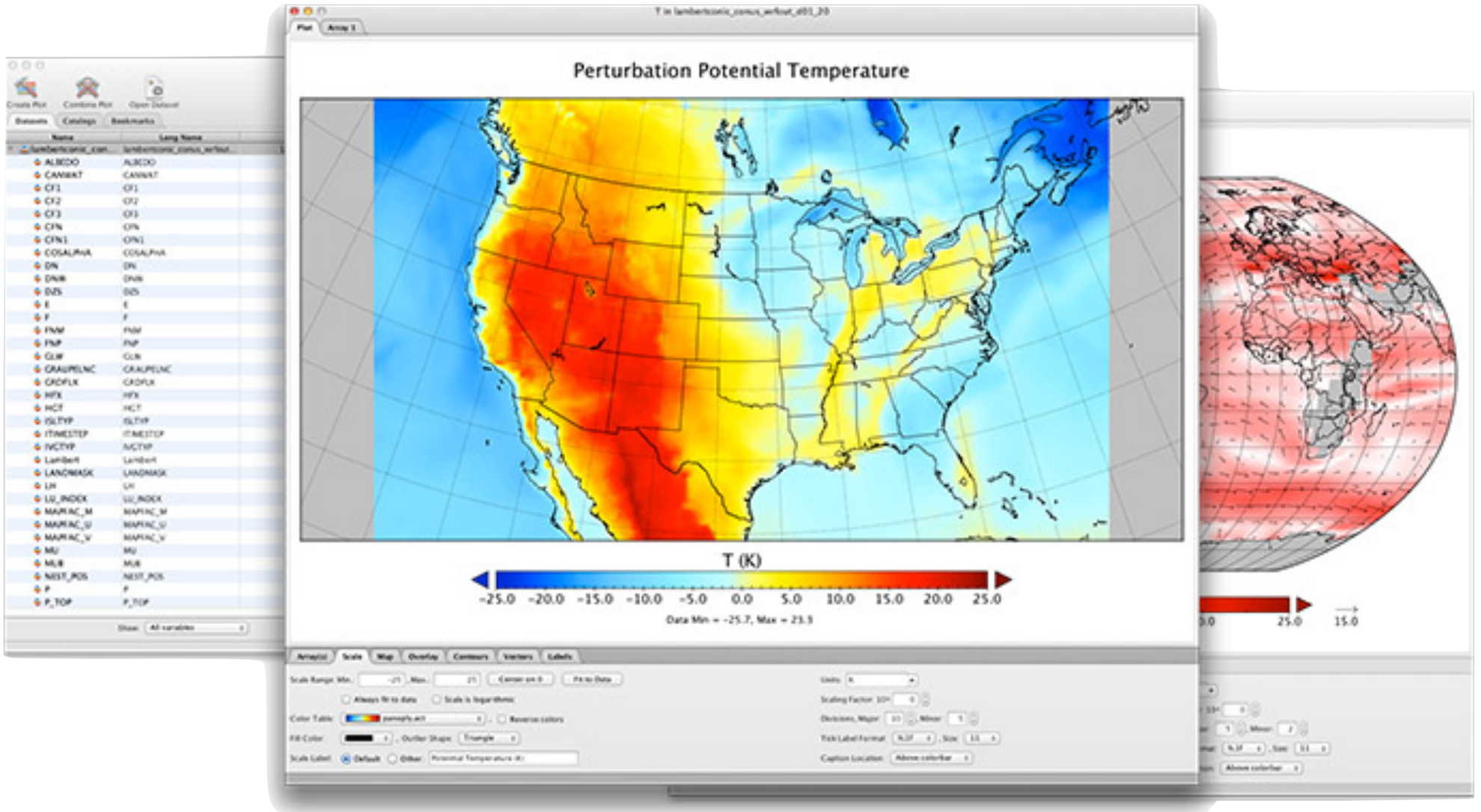
Download Options For Selection

3653 files

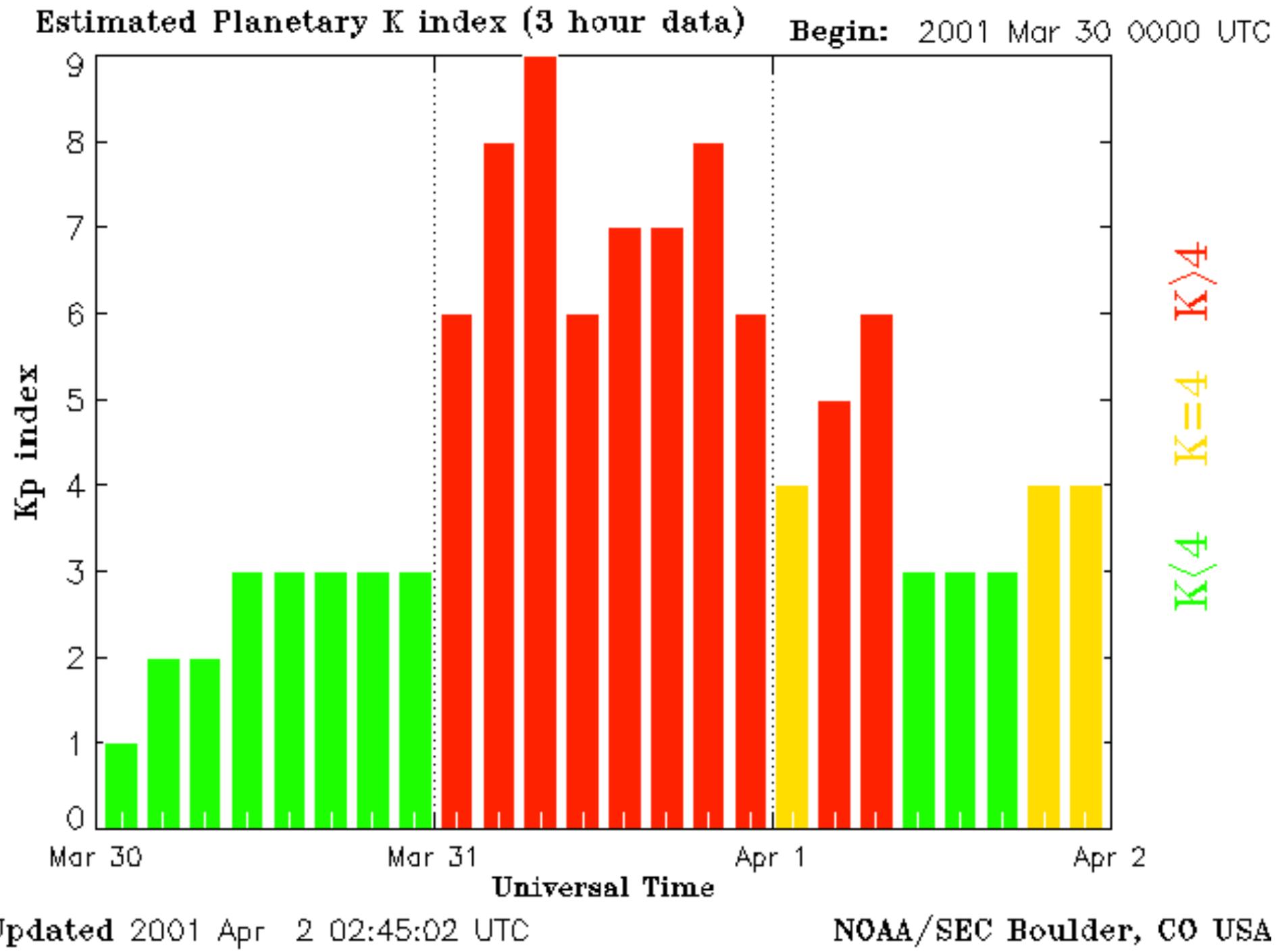
File	Size	Format	Location
f.e20.FXSD.f19_f19.001.cam.h1.2000-01-01-00000.nc	2.16 GB		SRM
f.e20.FXSD.f19_f19.001.cam.h1.2000-01-02-00000.nc	2.16 GB		SRM
f.e20.FXSD.f19_f19.001.cam.h1.2000-01-03-00000.nc	2.16 GB		SRM
f.e20.FXSD.f19_f19.001.cam.h1.2000-01-04-00000.nc	2.16 GB		SRM
f.e20.FXSD.f19_f19.001.cam.h1.2000-01-05-00000.nc	2.16 GB		SRM
f.e20.FXSD.f19_f19.001.cam.h1.2000-01-06-00000.nc	2.16 GB		SRM
f.e20.FXSD.f19_f19.001.cam.h1.2000-01-07-00000.nc	2.16 GB		SRM

Looking at WACCM-X output

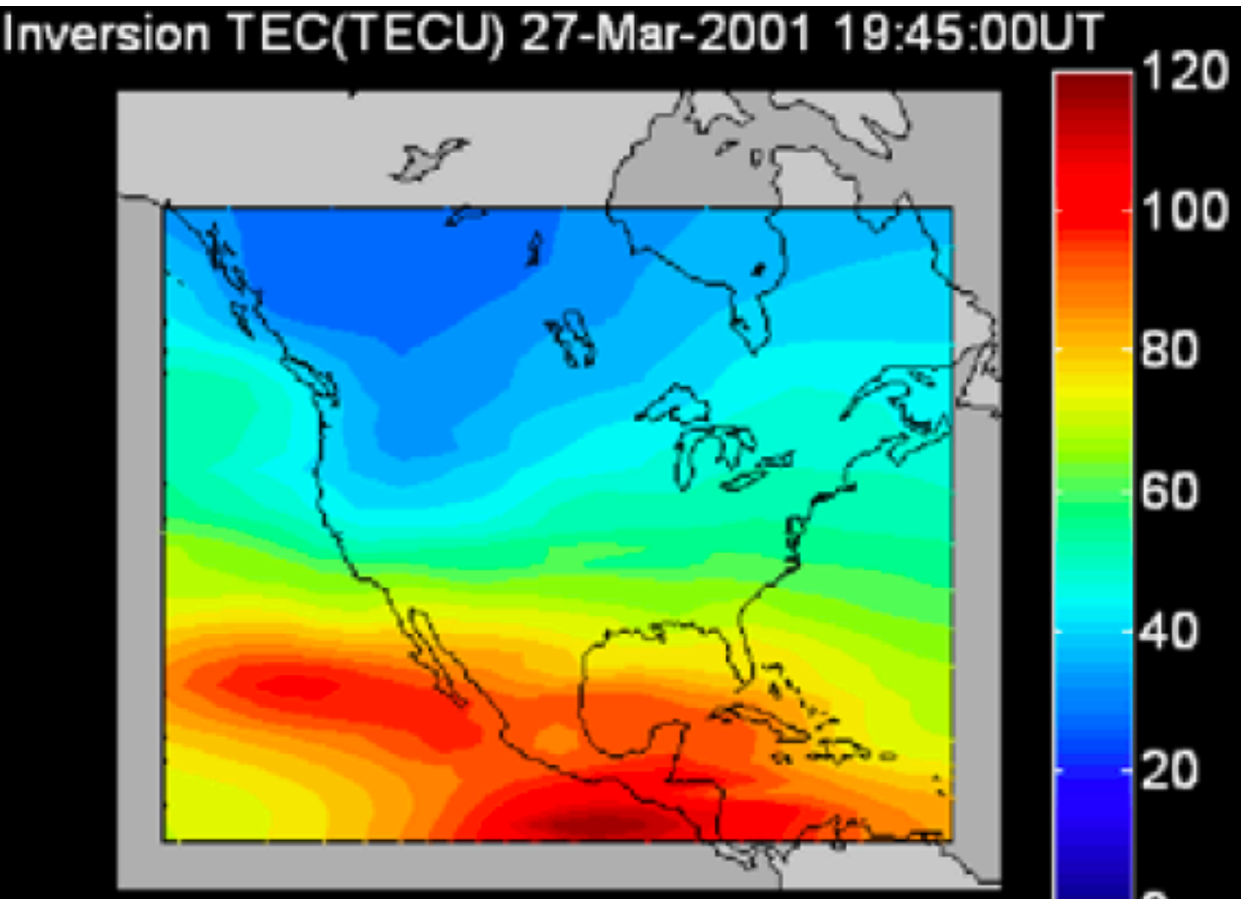
- WACCM-X history output files may be analyzed with standard analysis tools, including **Matlab**, **IDL**, **NCL**, and **NCO**.
- **Panoply**: netCDF data viewer for macOS, Windows, and Linux from NASA Goddard. Free download at https://www.giss.nasa.gov/tools/panoply/

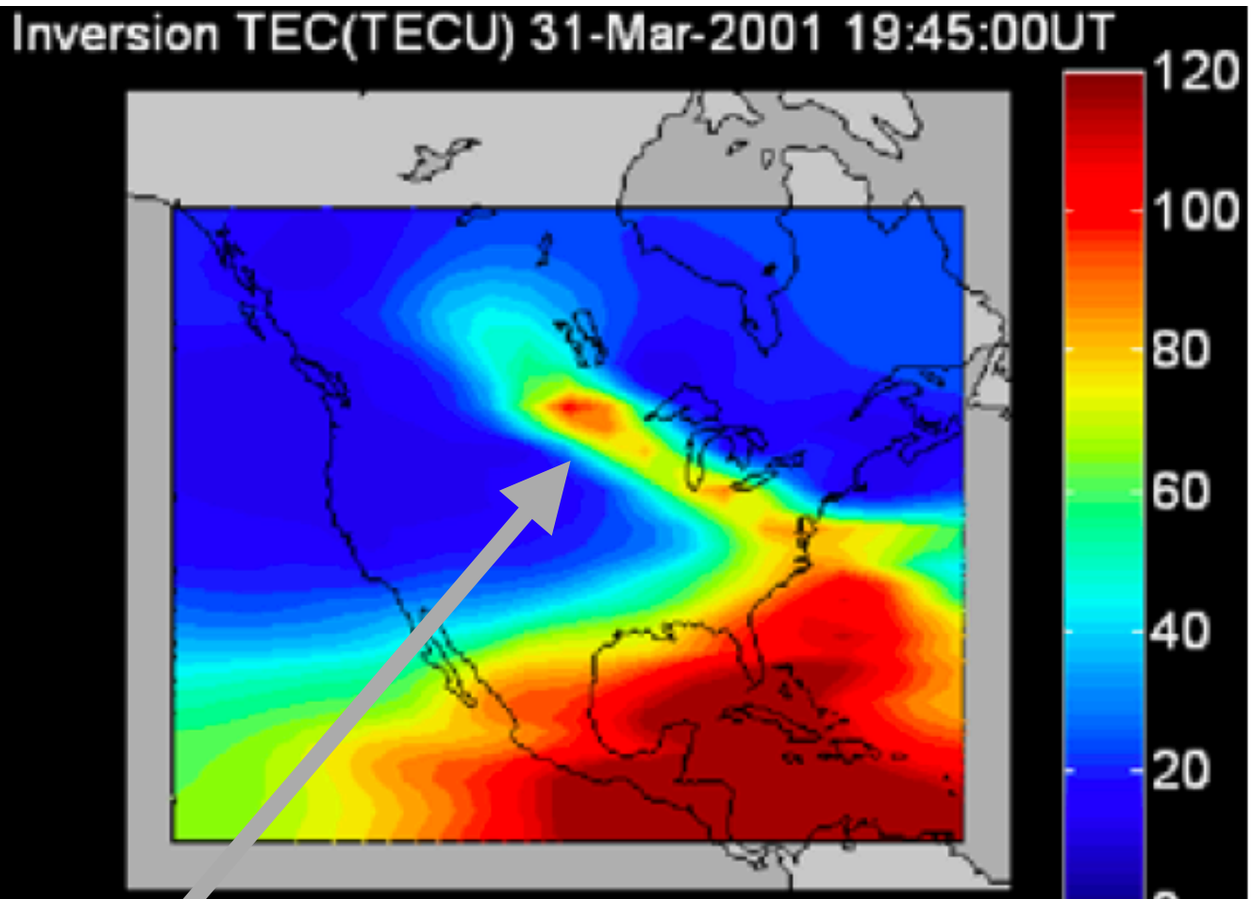


31 March 2001 Solar Storm

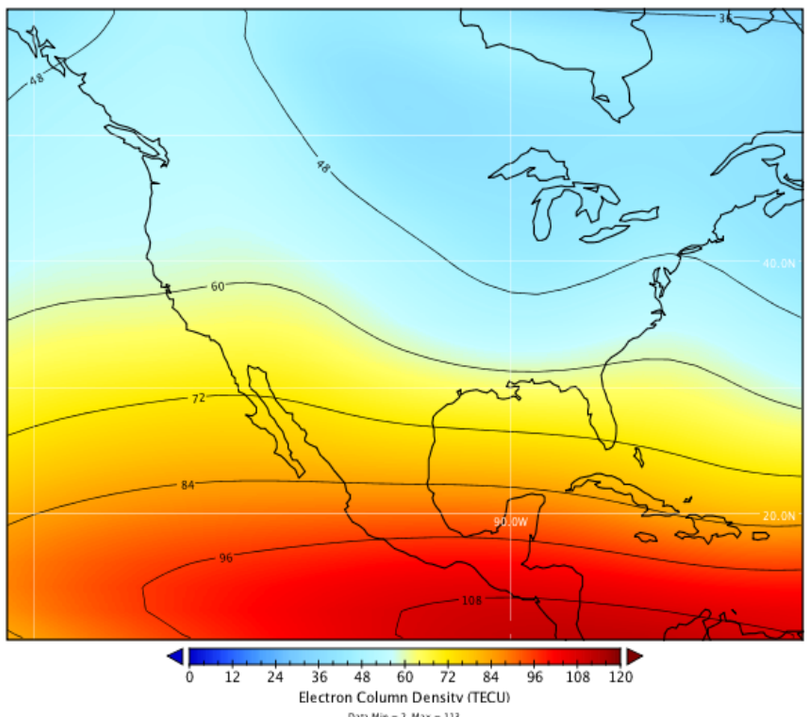


TEC (Fuller-Rowell et al., 2007)



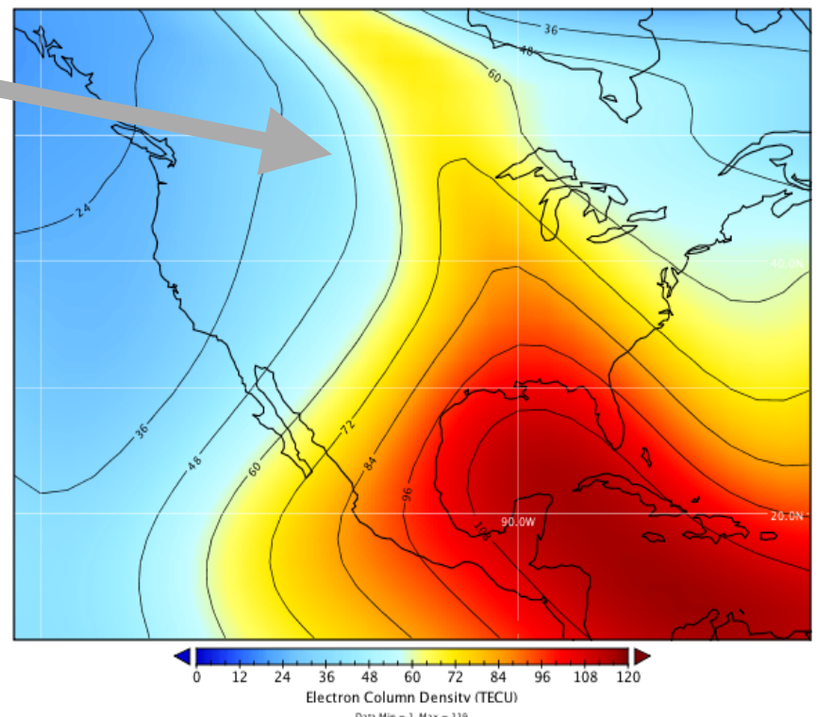


27 March 20:00UT



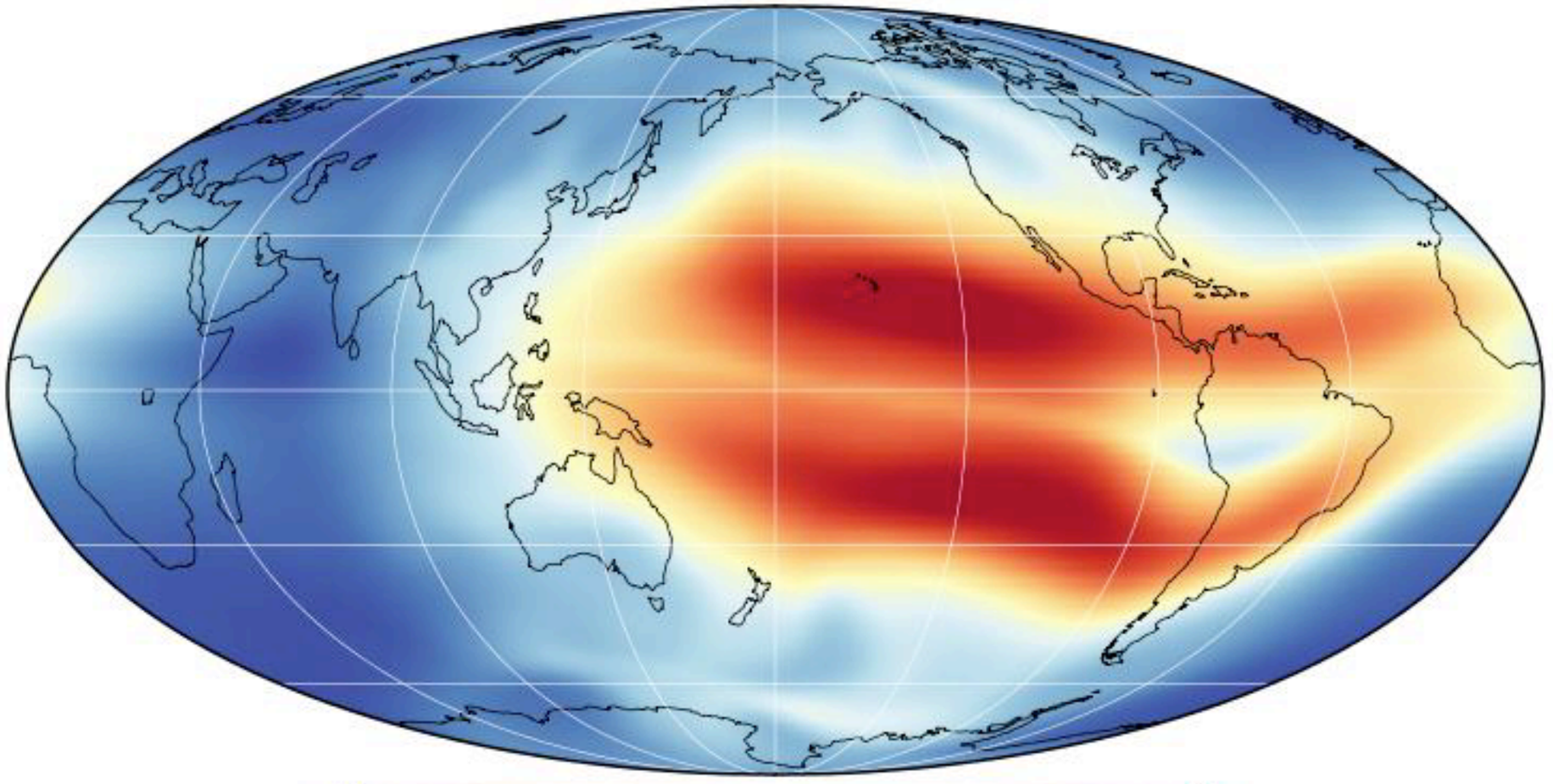
"Storm-enhanced density (SED) stretching from the east coast of the United States diagonally north and west across Canada to high latitudes."

31 March 20:00UT



Electron Column Density

Time: 2001-03-29 00:00 — 2001-03-29 01:00



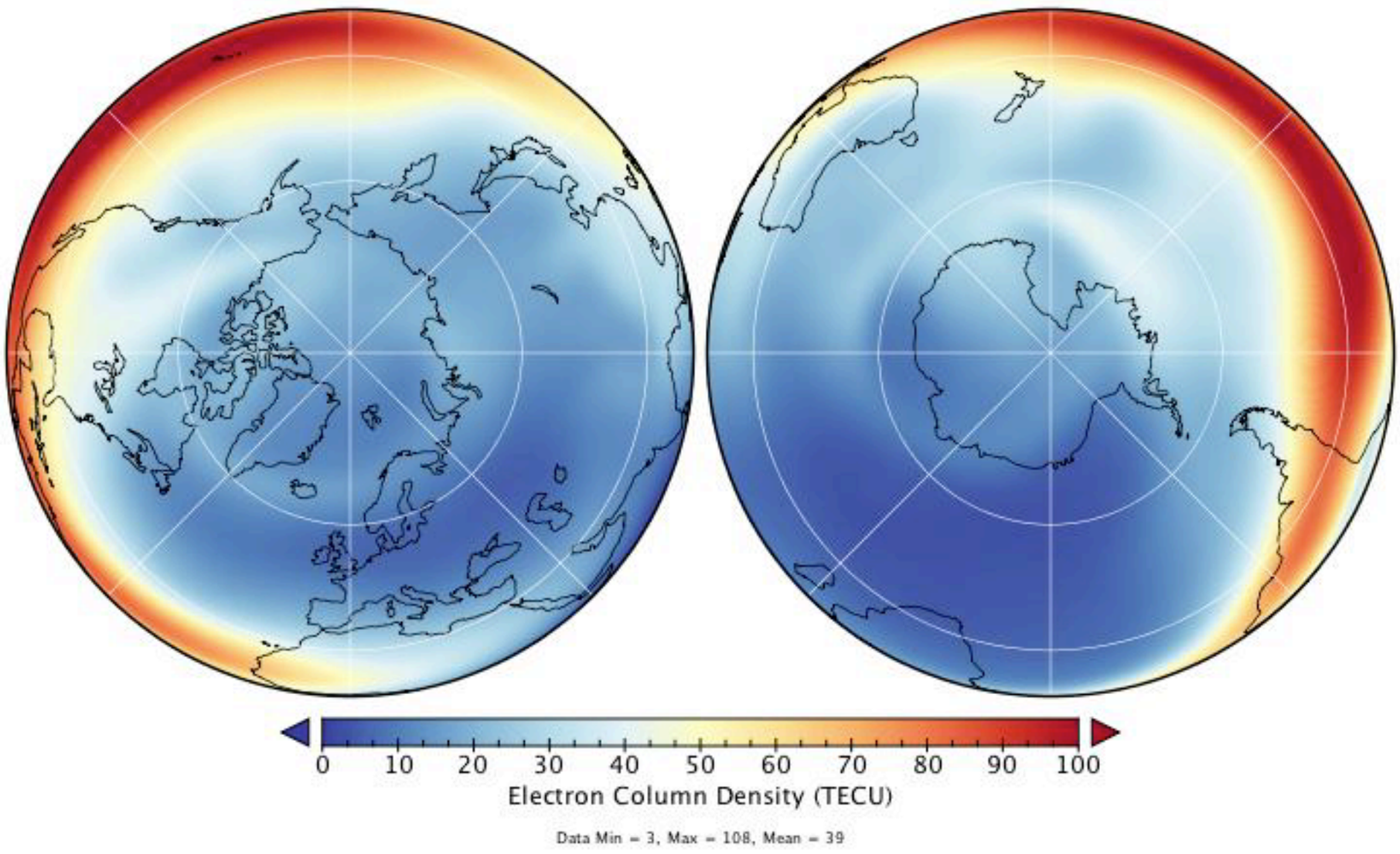
0 10 20 30 40 50 60 70 80 90 100

Electron Column Density (TECU)

Data Min = 3, Max = 108, Mean = 39

Electron Column Density

Time: 2001-03-29 00:00 — 2001-03-29 01:00



Data Min = 3, Max = 108, Mean = 39

●●○○○ Sprint LTE 9:45 PM 92%

Cancel App Store Store

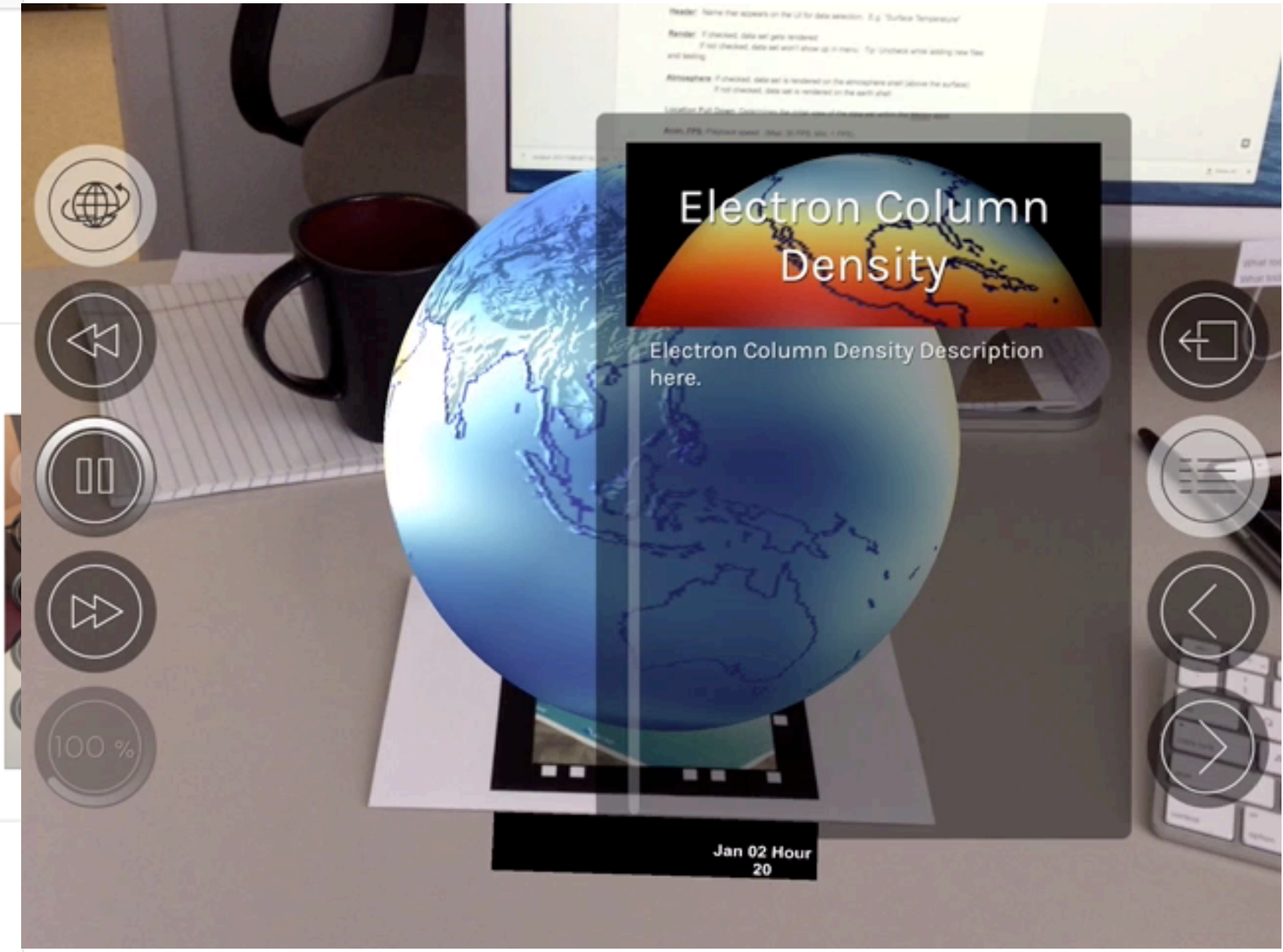
Meteo AR 4+

University Corporation for At... >

OPEN

Details | Reviews | Related

iPhone

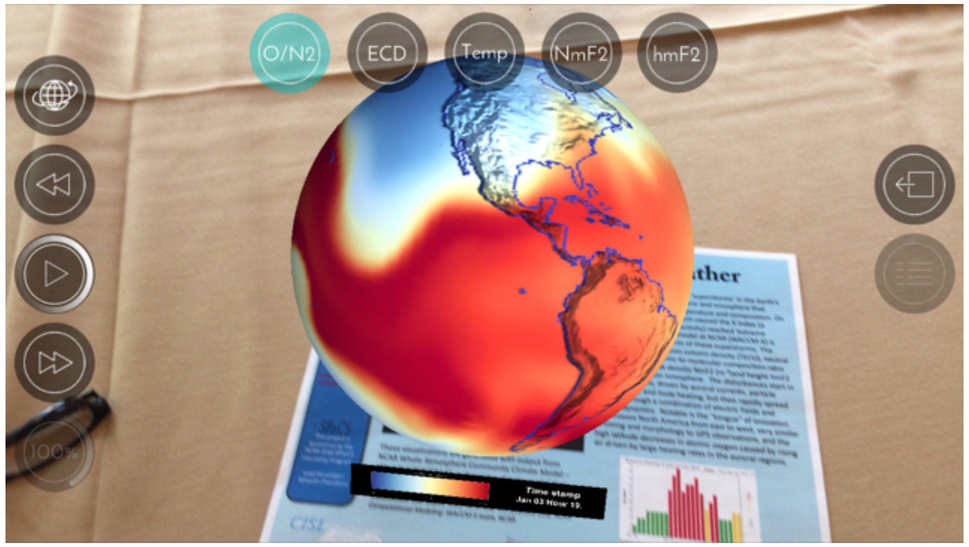


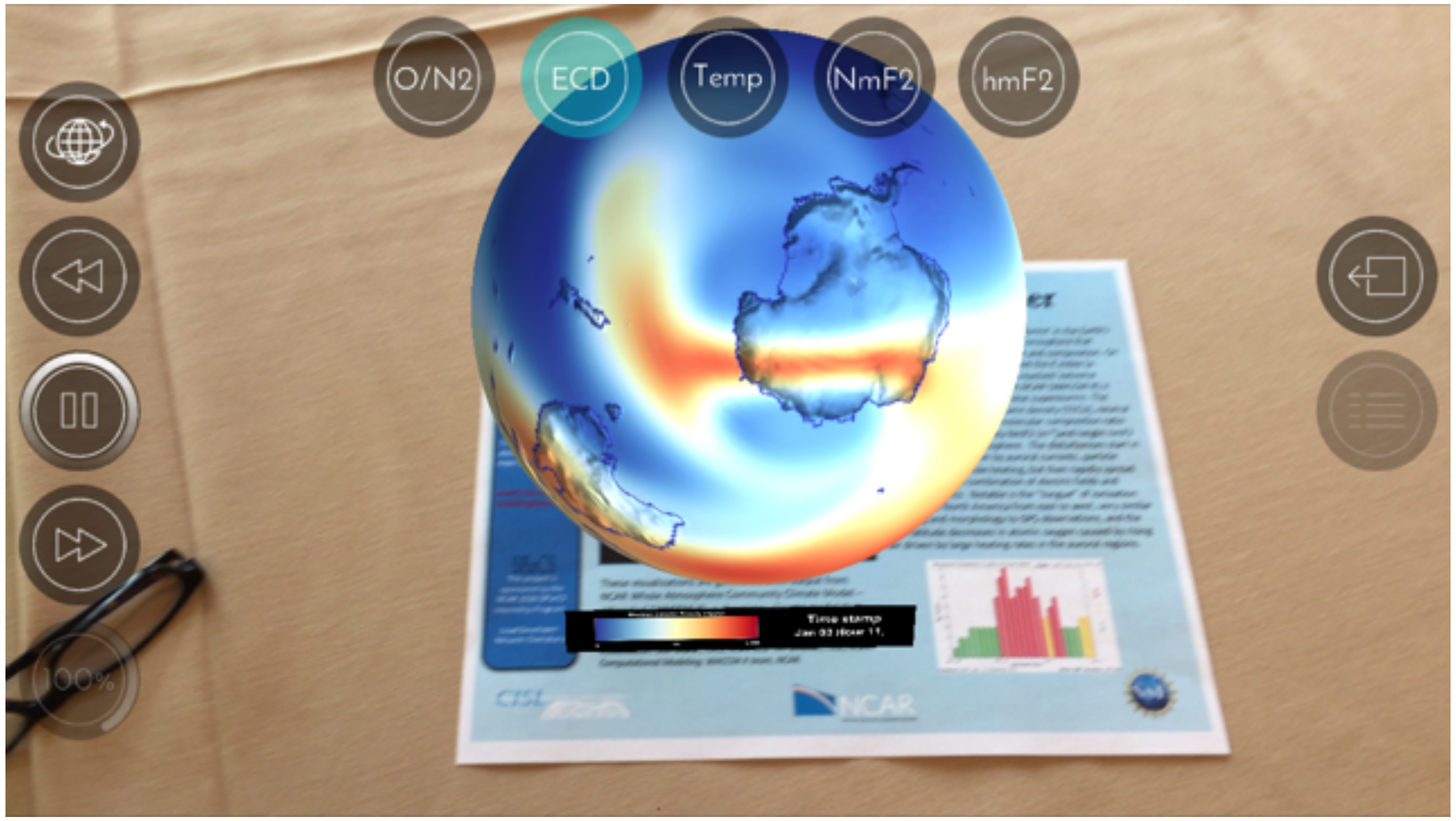
Description

The Meteo AR app provides an Augmented Reality interface for exploring 3D earth science data sets and learning more about the complex environment we live in. Just point your iPhone or iPad's camera to one of our "science sheets" (link below) and se... more

Community Earth System Model

CESM





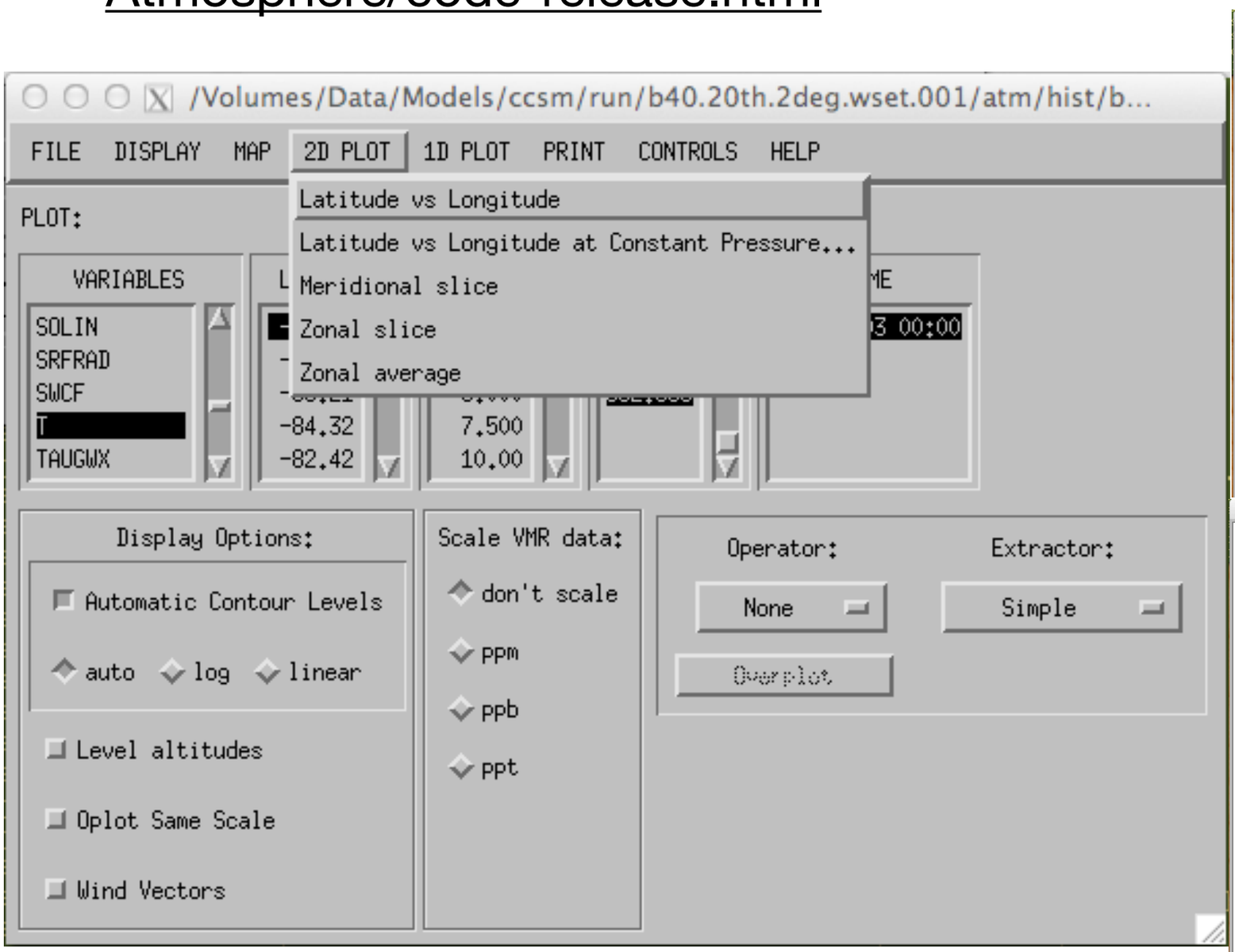
NCAR

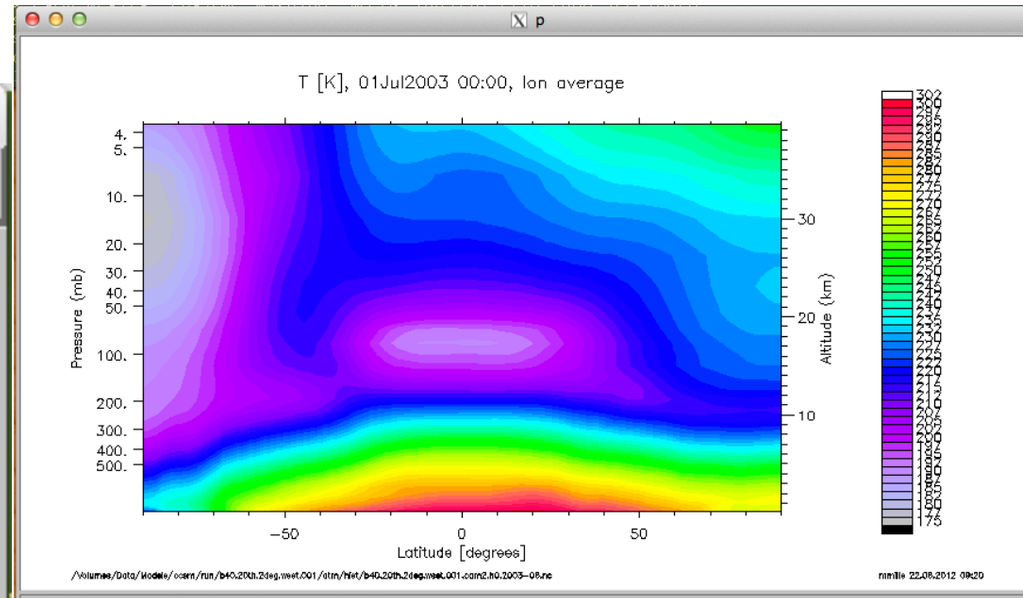
WACCM

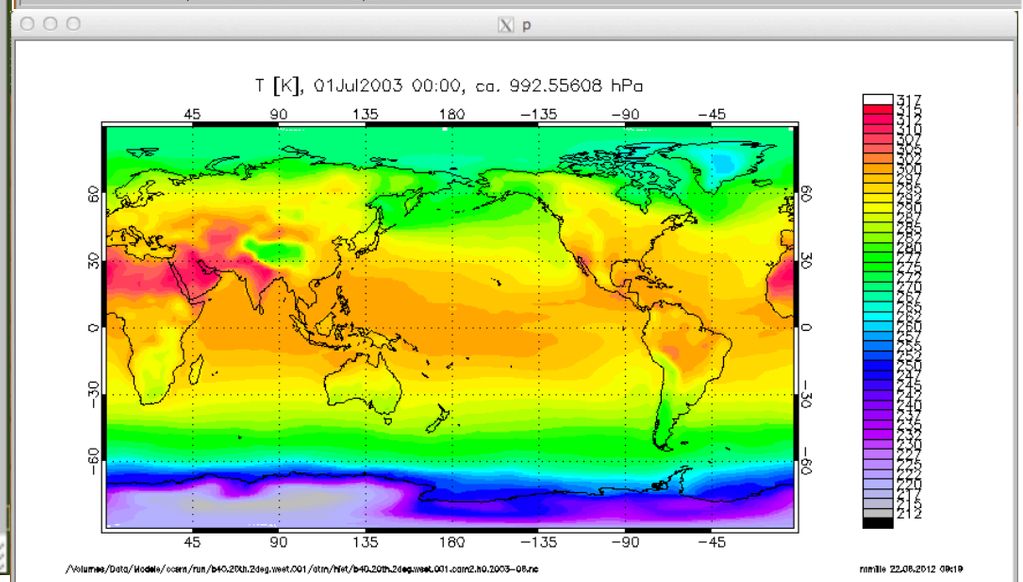
Whole Atmosphere
Community Climate Model

Looking at WACCM-X output: GEOV

- **GEOV** is an IDL-based viewer for geophysical history files created by NCAR's CAM, WACCM and MOZART models. GEOV can be downloaded from the WACCM webpage at http://www.cesm.ucar.edu/working_groups/Whole-Atmosphere/code-release.html







Looking at WACCM-X output: GEOV

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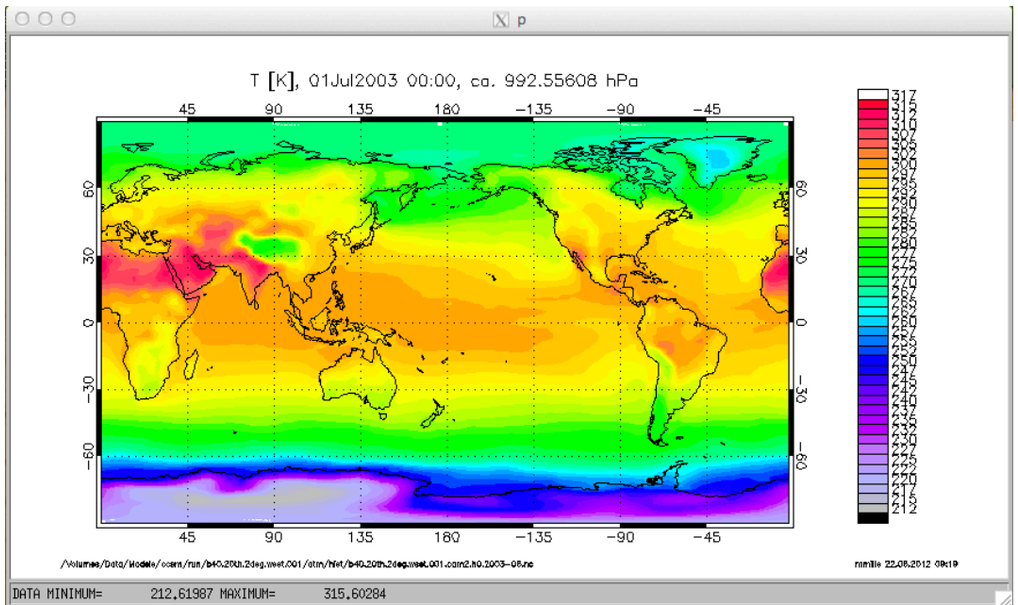
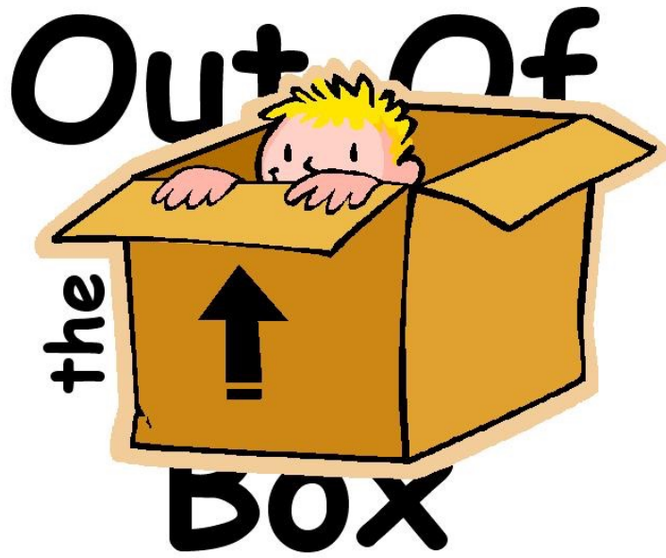
- Run GEOV on cheyenne with:

```
module load idl

setenv IDL_STARTUP ~fvitt/idl_startup

idl geov
```



Hardware and software requirements

- **Supported platforms**
  - CESM currently runs **"out of the box"** on NCAR machines (**cheyenne** and **yellowstone**), as well as a number of other computing platforms
  - Always review the model version release notes and DiscussCESM Forums (https://bb.cgd.ucar.edu) for up-to-date machine specific issues.
- **Running CESM on other platforms**
  - Requires porting and software
    - Subversion, Fortran and C compilers, NetCDF library, MPI
  - See model version release notes and DiscussCESM Forums for guidance



out of the box = works immediately after installation without any modification

NCAR supercomputer access

- Large Allocation Requests
  - > 400,000 core-hours on Cheyenne
  - CISL accepts requests for large allocations of NCAR resources every six months, in **March** and **September**.

- Small Allocation Requests
  - ≤ 400,000 core-hours on the Cheyenne system
  - U.S. university researchers who are supported by NSF awards can request a small allocation **for each NSF award**.
  - Also available to **graduate students** and **post-docs** at U.S. universities; no NSF award or panel review is required.
  - Small requests typically receive a partial allocation **within a few business days**. Once the initial allocation is consumed, you can email alloc@ucar.edu to request additional core-hours up to a total allowed.

- Small Data Access Requests
  - Faculty and research staff at U.S. universities, U.S. non-profit research organizations, and UCAR affiliates can request read-only access to NCAR-housed data at no charge.
  - These accounts are granted sufficient access to read data from GLADE and HPSS for up to three years. They may be renewed by sending email to alloc@ucar.edu and stating the additional time period needed.

https://www2.cisl.ucar.edu/user-support/allocations/university-allocations

Basic Work Flow: Creating and Running WACCM-X

- If not running at NCAR, some one-time set-up steps are needed (not covered here):
  - Registration
  - Downloading the CESM code
  - Creating an input data root directory
  - Porting
- Creating and running a case
  - Create a new case
  - Invoke case.setup
  - Build the executable
  - Run the model and output data flow

Logging in to **cheyenne** and finding the source code

YubiKey authentication tokens enable authorized users to access a variety of UCAR resources. For detailed instructions, see:

https://www2.cisl.ucar.edu/user-support/authentication-and-security/yubikey

Logging in:

```
ssh -X -l username cheyenne.ucar.edu
```

Source code for released model versions can be found here:

```
ls /glade/p/cesm/releases
```

When released, CESM2.0 will be there under cesm2_0_0. To create a new case, go to the "cime/scripts" subdirectory under the model version source code directory:

```
cd /glade/p/cesm/releases/cesm2_0_0/cime/scripts
```

There you will find the tool used to create a new run: **create_newcase**.

Work Flow: Super Quick Start

WACCM-X can be run with a set of 4 commands.

Set of commands to build and run the model on Cheyenne:

- **Go into the scripts directory in the source code:**

```
cd /glade/p/cesm/releases/cesm2_0_0/cime/scripts
```

1. **create a new case in the directory "cases/cheyenne" in your home directory:**

```
./create_newcase --res f19_f19 --compset FXHIST
--case ~/cases/cheyenne/f.e20.FXHIST.f19_f19.001
```

Go into the case you just created in the last step:

```
cd ~/cases/cheyenne/f.e20.FXHIST.f19_f19.001
```

2. **invoke case.setup**

```
./case.setup
```

3. **build the executable**

```
./case.build
```

4. **submit your run to the batch queue**

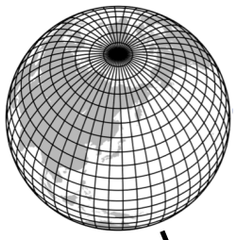
```
./case.submit
```

Creating a new case

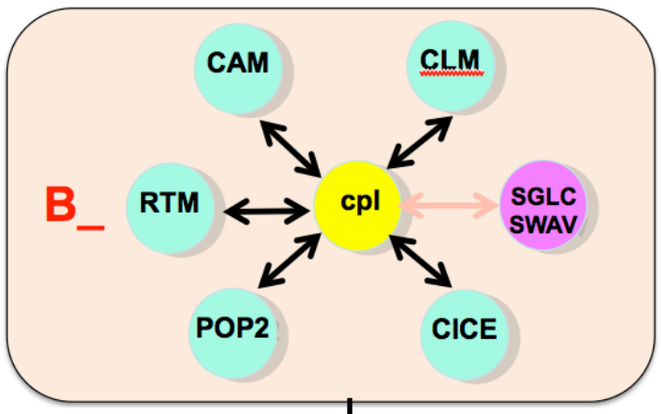
In the cime/scripts directory, **create_newcase** is the tool that generates a new model case.

create_newcase requires **3 arguments**:

Which resolution?



Which model configuration ? Which set of components ?



What is the casename ?


```
./create_newcase --res f19_f19 --compset FXHIST
--case ~/cases/cheyenne/f.e20.FXHIST.f19_f19.001
```

To check the current syntax of create_newcase:

```
./create_newcase --help
```

What is a compset?

“FXHIST” is an example of a component set, or “compset”, which defines the configuration of the CESM component models: atmosphere, land, ocean, sea ice, and land ice.

All WACCM-X components use non-interactive data models for ocean and sea ice, and do not include interactive land ice. Such compsets all begin with the letter “F”.

To list available WACCM-X compsets, while under cime/scripts type:

```
./query_config --compsets | grep %WXIE
```

short name long name

```
FXHIST       : FRC1_CAM40%WXIE_CLM45%SP_CICE%PRES_DOCN%DOM_RTM_SGLC_SWAV
```
WACCM-X historical 2000-2014

```
FX2000climo : 2000_CAM40%WXIE_CLM45%SP_CICE%PRES_DOCN%DOM_RTM_SGLC_SWAV
```
WACCM-X climatological present-day, static year 2000

```
FXSD         : SDYN_CAM40%WXIE_CLM45%SP_CICE%PRES_DOCN%DOM_RTM_SGLC_SWAV
```
WACCM-X nudged with specified dynamics (SD) 2000-2009

For more help on query_config:

```
./query_config --help
```

What horizontal resolution does WACCM-X use?

WACCM-X runs at 1.9° latitude x 2.5° longitude, which is abbreviated as “f19_f19”

To list the grids available:

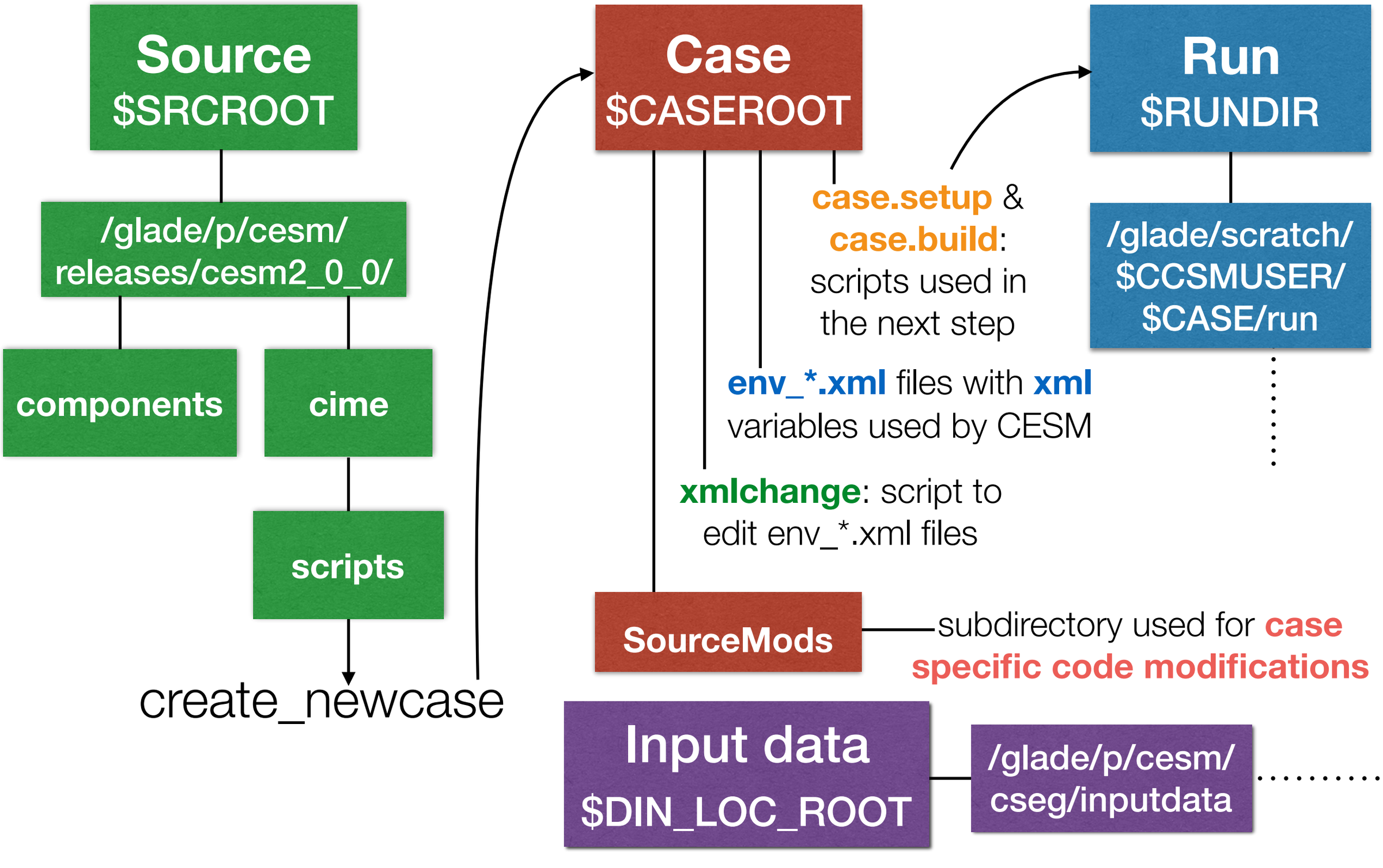
```
./query_config –grids
```

```
    alias: f19_f19 (only for compsets that are not _POP )
      non-default grids are: atm:1.9x2.5  lnd:1.9x2.5  ocnice:1.9x2.5
      mask is: gx1v6
```

Again, to create a WACCM-X case:

```
./create_newcase –compset FXHIST –res f19_f19
-case ~/cases/cheyenne/f.e20.FXHIST.f19_f19.001
```

Overview of directories



Compiling: Setup & Build

After creating your case, go to the case directory:

```
cd ~/cases/cheyenne/f.e20.FXHIST.f19_f19.001
```

Set up the case:

```
./case.setup
```

Build the case:

```
./case.build
```

Problems? Try:

```
./case.setup --reset
./case.build --clean
./case.build
```

Is this case ready to run?

- `xmlquery BUILD_COMPLETE --full`

```
   BUILD_COMPLETE: value=TRUE
      valid_values: ['FALSE', 'TRUE']
       description: Status output: if TRUE, models have been built
successfully.  (DO NOT EDIT)>
```

- `xmlquery STOP_OPTION,STOP_N --full`

```
STOP_OPTION: value=ndays
   valid_values: ['none', 'end', 'nminutes', 'nhour', 'nmonths', 'never',
   'nhours', 'nseconds', 'nstep', 'nyear', 'nmonth', 'nminute', 'nsecond',
   'ifdays0', 'date', 'nyears', 'nday', 'nsteps', 'ndays']
   description: Sets the run length along with STOP_N and STOP_DATE

STOP_N: value=5
   description: Provides a numerical count for $STOP_OPTION.
```

About env_*.xml files

- env_*.xml files contain variables used by scripts. Some can be changed by the user.
  - **env_case.xml: set by create_newcase and cannot be modified**
  - **env_mach_pes.xml: specifies layout of components**
  - **env_build.xml: specifies build information**
  - **env_batch.xml: sets arguments for batch submit command**
  - **env_run.xml: sets run time information (such as length of run, frequency of restarts, ...) User interacts with this file most frequently.**

- **Here's a snippet of the env_run.xml file:**

```
<!--"sets the run length in conjunction with STOP_N and STOP_DATE, valid values: none,never,nst
eps,nstep,nseconds,nsecond,nminutes,nminute,nhours,nhour,ndays,nday,nmonths,nmonth,nyears,nyea
r,date,ifdays0,end (char) " -->
<entry id="STOP_OPTION"   value="ndays"  />

<!--"sets the run length in conjunction with STOP_OPTION and STOP_DATE (integer) " -->
<entry id="STOP_N"   value="5"  />
```

CESM will run for 5 days

"id" - variable name

"value" – variable value

- **To modify a variable in an xml flle, use xmlchange**
  - **xmlchange STOP_N=20**

Okay, let's run!

```
./case.submit
```

Monitor the job status:

```
qstat -u $USER
```

```
                                                                  Req'd  Req'd   Elap
Job ID          Username Queue    Jobname    SessID NDS TSK Memory Time  S Time
--------------- -------- -------- ---------- ------ --- --- ------ ----- - -----
1297725.chadmin marsh    regular  f.e20.FXSD  32730   8 288    --  12:00 R 00:00
1297726.chadmin marsh    regular  f.e20.FXSD     --    1  36    --  12:00 H   --
```

Kill the running job and resubmit?

```
qdel 1297725
./case.submit
```

```
Current throughput is ~0.4 model years / wallclock day
```

Questions?